CHM129

Entropy and Gibbs Free Energy

1. Discuss with your neighbors whether the signs of ΔS for the following processes are expected to be positive or negative:

a) ice melts

$\Delta S > 0$

b) the temperature of a solid is lowered by 25°C.

$\Delta S < 0$

c) water evaporates from a beaker

$\Delta S > 0$

d) $HCl_{(g)}$ dissolves in water

$\Delta S < 0$

e) $4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

$\Delta S > 0$

f) $CaO_{(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)}$

$\Delta S < 0$

g) $CH_3OH_{(g)} \rightarrow CH_3OH_{(l)}$

$\Delta S < 0$

h) $2\ SO_{2(g)} + O_{2(g)} \rightarrow 2\ SO_{3(g)}$

$\Delta S < 0$

i) $CaCl_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)}$

$\Delta S > 0$

2. Use $\Delta S_{surr}°$ and $\Delta S_{Rxn}°$ to determine the $\Delta S_{univ}°$ at 298 K. Is the process spontaneous?

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$$

	$\Delta H°_f$ (kJ/mol)	S° (J/mol.K)
H_2	0	+130.58
O_2	0	+205.0
H_2O	-241.82	+188.83

$\Delta S°_{sys}$

$$\Delta S°_{Rx} = \Sigma n S°_{prod} - \Sigma m S°_{react.}$$

$$= \left(2\text{ mol} \times 188.83 \tfrac{J}{mol \cdot K}\right) - \left[\left(2\text{ mol} \times 130.58 \tfrac{J}{mol \cdot K}\right) + \left(1\text{ mol} \times 205.0 \tfrac{J}{mol \cdot K}\right)\right]$$

$$\Delta S°_{Rx} = -88.5\ J/K$$

$$\Delta H°_{Rx} = \Sigma n \Delta H°_{f\ prod} - \Sigma m \Delta H°_{f\ react.}$$

$$= \left(2\text{ mol} \times -241.82 \tfrac{kJ}{mol}\right) - \left[\left(2\text{ mol} \times 0\ kJ/mol\right) + \left(1\text{ mol} \times 0\ kJ/mol\right)\right]$$

$$\Delta H°_{Rx} = -483.64\ kJ = -483{,}640\ J$$

$$\Delta S°_{surr} = \frac{-\Delta H°_{R}}{T} = \frac{-483{,}640\ J}{298K} = 1{,}620\ J/K$$

$$\Delta S°_{univ} = \Delta S°_{sys} + \Delta S°_{surr} = -88.5\ J/K + 1{,}620\ J/K = \underline{1{,}530\ J/K}$$